

CLAIMS

What is claimed is:

1. A method of increasing the concentration of a gas in a first atmosphere and decreasing the concentration of said gas in a second atmosphere, the method comprising

5 (A) providing an atmosphere control member (ACM) having first and second surfaces; and

(B) placing the first atmosphere adjacent the first surface and the second atmosphere adjacent the second surface, the first and second atmospheres containing different proportions of said gas (including the possibility that one of the
10 atmospheres contains substantially none of said gas);

wherein at least one of the first and second atmospheres flows over the surface of the ACM adjacent thereto.

2. A method according to claim 1 which has at least one of the following characteristics

15 (i) one of the first and second atmospheres contains p% by volume of CO₂, where p is at least 3, e.g. 3-15, and the other atmosphere contains less than p%, e.g. 0-5%, preferably substantially 0%, by volume of CO₂;

(ii) one of the first and second atmospheres contains q% by volume of O₂, where p is at least 15, e.g. 15-25, preferably substantially 21, and the other atmosphere contains less
20 than q%, e.g. 2-15 % or 3-10 %, by volume of O₂;

(iii) one of the atmospheres is an atmosphere within a sealed container containing a respiring biological material, e.g. (a) a packaging atmosphere in direct contact with the respiring biological material, or (b) an intermediate atmosphere in contact with the exteriors of a plurality of sealed containers, each of which includes a second ACM and contains a
25 respiring biological material; and the other atmosphere is air or oxygen-enriched air;

(iv) the rate at which at least one of the atmospheres flows over the surface of the ACM is changed, discontinuously or continuously (e.g. in response to one or more sensors which measure the concentration of at least one gas in at least one of the atmospheres before and/or after one or both of the atmospheres have flowed over the ACM), the rate preferably
30 being one or more of

(a) the volume of the atmosphere passing through a closed chamber including the ACM, and

(b) the average speed at which the atmospheres flows over the ACM;

(v) the ACM is part of a closed chamber and one of the atmospheres is caused to flow
35 through the chamber, and preferably the method has one or more of the following features

(a) the atmosphere flows through the chamber at a rate of 5-500, e.g. 10- 300 or 20-200 cfm (0.14-14., e.g. 0.28-8.4 or 0.56-5.6 m³/min),

5 (b) the atmosphere flows through the chamber from at least one inlet to at least one outlet, the inlet and outlet being placed so that a straight-line joining the inlet and the outlet crosses the ACM, the atmosphere preferably flowing at a rate such that the average speed of the atmosphere flowing across the ACM (defined as the volume of the atmosphere passing through the chamber per minute divided by the cross-section of the chamber at right angles to said straight line) is 50 to 5000, e.g. 200 to 2500, inch/min (1.25 to 125, e.g. 5 to 65, m/min),

10 (c) the atmosphere flows through the chamber at a rate such that the volume of the atmosphere flowing through the chamber is 0.0025 to 0.25, e.g. 0.005 to 0.1 or 0.005 to 0.04, ft³ per in² (0.06 to 6.4, e.g. 0.12 to 2.5 or 0.12 to 1.0 mm³ per mm²) of ACM exposed to said atmosphere,

15 (d) the chamber is a rectangular parallelepiped which comprises two major faces and four minor faces; and in which at least one of the major faces includes an ACM, a first minor face includes at least one inlet for an incoming atmosphere in, and a second minor face opposite the first minor face includes at least one outlet for an outgoing atmosphere, and

20 (e) the chamber comprises (i) a generally cylindrical surface which comprises the ACM, and (ii) two opposite end faces, one of the end faces including at least one inlet for an incoming atmosphere and the other of the end faces including at least one outlet for an outgoing atmosphere.

25 3. A method according to claim 1 or 2 which has at least one of the following characteristics

(a) the area of the ACM is at least 100 in² (0.06 m²), particularly at least 1000 in² (0.65 m²), for example an area of 100 to 20,000 in² (0.06 to 13 m²), for example 1000 to 10,000 in² (0.65 to 6.5 m²),

30 (b) one of the atmospheres is the atmosphere within a container having a volume of at least 1 m³, particularly at least 40 m³, for example a shipping or trucking container, and the other atmosphere is preferably air or oxygen-enriched air,

(c) the ACM comprises a microporous film having a polymeric coating thereon,

(d) step (A) comprises providing a first ACM having a relatively low R ratio, e.g. of 1 to 2.3 or 1.3 to 2.0 and a second ACM having a higher R ratio, e.g. of 1.5 to 5.0, or 2.0 to 4.0, or 2.3 to 3.0; and step (B) comprises a step (B1) in which the atmospheres are placed adjacent to the first ACM and a step(B2), which may be before or after step (B1), in which the atmospheres are placed adjacent to the second ACM.

4. A container system comprising

(1) a sealed container having an exterior surface, and

(2) within the sealed container, a respiring biological material and an inner atmosphere,

the container having an internal atmosphere control member (ACM) which, when gases are passing through the ACM, has

(a) a first surface which is in direct contact with the inner atmosphere, and

(b) a second surface which is not in direct contact with the inner atmosphere and is not part of the exterior surface of the container.

5. A container system according to claim 4 which can be used to carry out the method of any one of claims 1 to 3.

6. A container system according to claim 4 or 5 which has at least one following characteristics

(a) it comprises pressure-generating means for supplying gas to the second surface of the ACM,

(b) it comprises a metering device for changing the rate at which gas can be supplied to the second surface of the ACM,

(c) it comprises a plurality of sources of different gases and a corresponding plurality of metering devices for changing the rate at which gas can be supplied from each of the sources to the second surface of the ACM,

(d) it comprises a plurality of internal ACMs corresponding to the plurality of separate sources of different gases, each chamber comprising one of the plurality of the internal ACMs, the internal ACMs preferably having different permeability characteristics,

- (e) the internal ACM is part of a reusable module which has been assembled separately from the container, e.g. a module including a rigid frame, preferably a module which is secured inside a container having at least one rigid wall,
- (f) the respiring biological material is placed within the container without any additional packaging or in packaging which has no substantial effect on the atmosphere in direct contact with the biological material,
- (g) the respiring biological material is packed in a plurality of ACM-containing sealed inner containers, and the inner containers are placed within the sealed container having the internal ACM,
- (h) the ACM comprises a microporous film having a polymeric coating thereon, and
- (i) the respiring biological material is bananas.
7. A container, for example a shipping or transportation container, which can be sealed and which, when sealed, has an exterior surface and an inner atmosphere within the sealed container; and which comprises an internal atmosphere control member (ACM) which has
- (a) a first surface which is in direct contact with the inner atmosphere, and
- (b) a second surface which is not in direct contact with the inner atmosphere and is not part of the exterior surface of the container.
8. A method of storing (including ripening) a respiring biological material which comprises supplying gas to the second surface of the internal ACM of a sealed package obtained by sealing a container as defined in claim 7.
9. A reusable module which comprises a closed chamber including an ACM, and inlet for gas and an outlet for gas.
10. A reusable module according to claim 9 which has at least one of the following features
- (a) it comprises a rigid frame,
- (b) the inlet and outlet are placed so that a straight-line joining the inlet and the outlet crosses the ACM,
- (c) the chamber is a rectangular parallelepiped which comprises two major faces and four minor faces; and in which at least one of the major faces includes an ACM,

a first minor face includes at least one inlet for incoming gases, and a second minor face opposite the first minor face includes at least one outlet for outgoing gases, and
(d) the chamber comprises (i) a generally cylindrical surface which comprises the ACM, and (ii) two opposite end faces, one of the end faces including at least one
5 inlet for an incoming atmosphere and the other of the end faces including at least one outlet for an outgoing atmosphere.

11. An assembly for storing (including ripening) a respiring biological material, the assembly comprising

- 10 (1) an outer sealed gas-permeable container, and
(2) within the outer sealed container, at least one sealed inner package comprising
(a) a sealed inner gas-permeable container, and
(b) within the sealed inner container, a respiring biological material and a
15 packaging atmosphere around the biological material;
at least one of the outer container and the inner container including an ACM.

12. An assembly according to claim 11 which has at least one of the following characteristics

- 20 (a) each of the inner and outer containers includes an ACM,
(b) at least one of the inner container and the outer container includes a non-selective ACM, for example 1 to 10 holes of 50 to 600 gauge,
(c) the inner container includes a selective ACM and the outer container includes a non-selective ACM, or the outer container includes a selective ACM and the inner
25 container includes a non-selective ACM,
(d) there are at least 10, e.g. at least 20, substantially identical inner packages,
(e) the outer container includes an internal ACM, and
(f) the packaging atmosphere contains 4-12% O₂ and 14-16% CO₂, or 10-15% O₂ and 8-13% CO₂.

30 13. A method of storing (including ripening) a respiring biological material, the method comprising

- (A) preparing an assembly as defined in claim 11 or 12, and

(B) maintaining the assembly prepared in step (A) at a temperature and in an ambient atmosphere surrounding the outer container such that the packaging atmosphere has a desired composition.

5 14. A method according to claim 13 wherein the assembly is at a temperature of 2-5°C.

15. A method according to claim 13 or 14 which includes

10 (C) after step (B), unsealing the outer container and storing the inner container in air.

16. A method according to claim 15 wherein, in step (C), the inner container is stored in air at 18-21°C.